The Bearing-down Efforts and their Effects on Fetal Heart Rate, Oxygenation and Acid Base Balance.

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1. Clinical material. The study was performed in 12 primigravidas, with uncomplicated pregnancies in which labor started spontaneously at term. Membranes ruptured spontaneously after cervical dilatation had progressed beyond 6 cm, usually with full cervical dilatation (1). The fetus was single, in cephalic presentation. Cephalo-pelvic disproportion was discarded. All the newly born infants were in good condition. Their follow-up continues; their present age ranges between 1 and 8 months.

2. Methods.

2.1. The intrauterine pressure recording range was 0-200 mm Hg (fig. 2 and 3). The usual range 0-100 mm Hg does not enable to record the upper part of the bearing down efforts because the intrauterine pressure rises over 100 mm Hg.

2.2. The speed of the recording paper usually was 15 cm/min (fig. 3), sometimes 6 cm/min (fig. 2). These high paper speeds are needed for the accurate measurement of the duration of the efforts and of the interval between them. They also facilitate to visualize the effect of each effort on Fetal Heart Rate (FHR), which was recorded with an electrode inserted in the fetal scalp.

2.3. "Spontaneous" bearing down efforts. Mothers were instructed to perform expulsive efforts whenever they felt the urge to "push". The duration and force of the efforts was self regulated by the mother. The same applies for the timing of the efforts. Mothers were not instructed to close the glottis during the effort.

2.4. During the first stage of labor women were allowed to choose the most comfortable position (usually sitting, standing or walking) and to move freely (2). During the second stage of labor and delivery, mothers were sitting in the obstetrical chair designed at our Center (fig. 1) with the lower limbs flexed and the thighs in abduction. The chair was adjusted to the most comfortable position for the mother, who usually was already familiar with the chair and had been trained during prenatal visits.

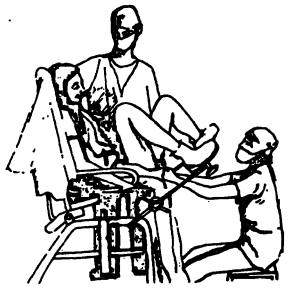

Fig. 1 - Position of the mother during second stage of labor and delivery. The husband provides emotional and physical support.

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2.5. Mothers required no analgesia or anesthesia except in 4 instances in which local perineal anesthesia was given for episiotomy.

2.6. During pregnancy, mothers and their husbands were educated and trained about their participation in labor and all were highly motivated to give birth with the method summarized here. The active participation and support provided by the husband and other relative(s) was most valuable for the psychological, emotional and physical well-being of the mother.

3. Characteristics of spontaneous bearing down efforts.

3.1. For analysis purposes, the record obtained during the second stage of labor was divided into three periods of equal duration (fig. 4).

3.2. The average number of efforts per uterine contraction was 4.29 and no significant difference was found between the three periods.

3.3. The average intrauterine pressure at the base of the efforts was 42 mm Hg without difference between the three periods. At the top of the efforts the average pressure was 88, 107 and 119 mm Hg, in the 1st, 2nd and 3rd periods respectively. The amplitude of the pressure rise caused by the efforts was 44, 67 and 75 mm Hg in the 1st, 2nd and 3rd periods. This rise in amplitude was statistically significant ($p < 0.001$). The expulsive pressure exerted by the abdominal muscles increased as the second stage of labor progressed.

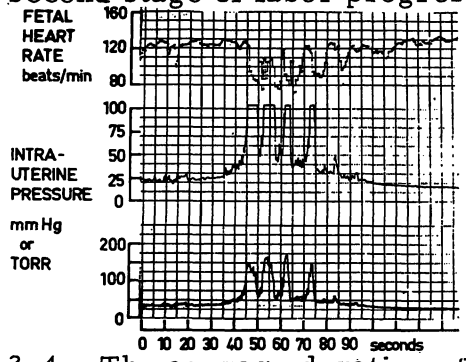

Fig. 2 - Record obtained in the second stage of labor. 4 spontaneous bearing-down efforts occur during one uterine contraction. They are fully recorded in the lower tracing. Each effort causes a transient fall in FHR. Paper speed 6 cm/min. The contraction caused a type I dip in FHR.

3.4. The average duration of the efforts at the base was 4.15, 4.64 and 5.78 seconds (fig. 4). At the top of the efforts the duration increased from 0.93 to 1.87 seconds, in the 1st and 3rd periods respectively. Both the duration at the base and at the top of the efforts increased significantly as the second stage progressed.

The duration of the "spontaneous" efforts (average 5 seconds at the base of efforts) is much shorter than the duration of the effort "directed" by the attending obstetrician or midwife, which are usually longer than 10 seconds. Since during the effort the mother is in apnea, the longer the duration of the effort, the more marked will be the fall of pO_2 and the rise in pCO_2 in maternal blood.

3.5. The surface area within the record of the effort increased from 121 to 300 (mm Hg x seconds) from the first to the third period. This almost threefold increase is highly significant ($p < 0.001$) and indicates the increased expulsive "work" (integration of time and pressure) performed by the abdominal muscles as the second stage progresses.

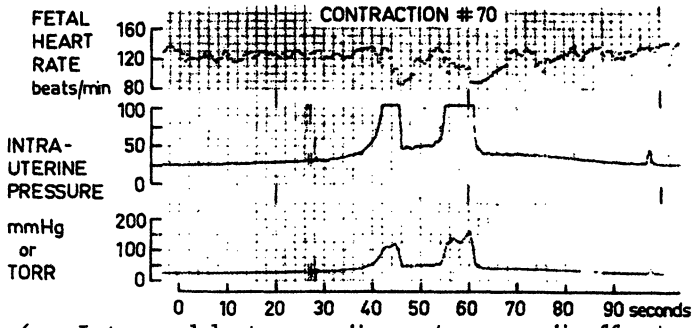

Fig. 3 - Same as in fig. 2. During the uterine contraction two efforts directed by the obstetrician were performed. The second effort lasted 8 seconds. Paper speed 15 cm/min. The contraction did not cause a type I dip in FHR.

3.6. Interval between "spontaneous" efforts.

3.6.1. During each uterine contraction the average interval is 2 seconds. During this interval the mother makes several breathing movements which contribute to minimize the fall of pO_2 and the rise in pCO_2 in maternal arterial blood during the second stage of labor.

3.6.2. The interval between the last effort of one contraction and the first effort of the subsequent contraction diminish from 156 to 109 seconds from the first to the third periods of the second stage. The shortening of this interval is due to the increased frequency of uterine contractions as the second stage advances. In one woman efforts occurred in the interval between contractions.

3.7. The average pressure at the onset of the first effort of each contraction remained remarkably constant, close to the average value of 32 mm Hg; this is the threshold pressure which elicits the urge to push and triggers the expulsive effort in non-medicated mothers without anesthesia.

3.8. The average pressure at the end of the last effort of each contraction also remained almost invariable throughout the second stage, close to the mean value of 41 mm Hg.

4. Effects of bearing down efforts on FHR.

Very frequently each effort caused a distinct, transient fall in FHR ("dip caused by effort"). These dips, when present, have a one to one relation with the causing efforts. Sometimes, the onset, bottom and recovery of the dip are delayed 1 to 10 seconds in relation to the effort (figs. 2 and 3). The "dips caused by the efforts" may start from a type I dip ("early deceleration") coinciding with one uterine contraction (fig. 2). In such cases the amplitude of the type I dip appears to be augmented by the additional falls caused by the efforts. When the recording paper has a low speed (1 to 3 cm/min) the dips caused by efforts might be interpreted as irregularities in the dip and their true cause has been overlooked.

When the uterine contraction does not cause a type I dip (fig. 3), the "dips caused by the efforts" start from the baseline FHR and when recorded on paper at low speed, may be interpreted as an irregular type I dip.

5. pO_2 and acid base balance in fetal blood at birth.

In the present study, the average values of pO_2 are 27 mm Hg in umbilical artery (SE 1.5 mm Hg) and 33 mm Hg in umbilical vein (SE 1.2 mm Hg). These figures are higher than the values usually quoted as "normal" (4). A similar statement can be made for the pH which is 7.33 in the umbilical

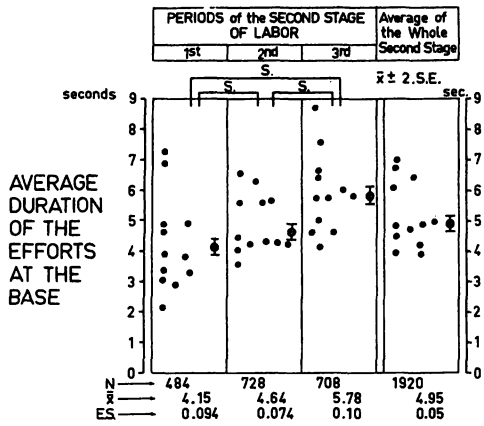

Fig. 4 - The average duration of the bearing-down efforts at the base increases from the first to the third period of the second stage of labor.

artery (SE 0.013 pH units) and 7.38 in the umbilical vein (SE ± 0.012).

The average pCO_2 is 39 mm Hg in umbilical artery, and 35 mmHg in umbilical vein. These values are lower than those reported as "normal"(4). A similar statement holds true for base deficit at birth in umbilical vessels.

Some factors contributing to the high value of fetal pO_2 and pH at birth (and low pCO_2 and Base Deficit) may be the short duration of the spontaneous bearing down efforts (see 3.4) and maternal breathing between consecutive efforts (see 3.6.1). Other factors may be the sitting position which avoids compression between the uterus and the spine, and of the inferior vena cava and the aorta and iliac arteries which may occur in the lithotomy position. Such compression might interfere with placental perfusion with maternal blood. Another possible factor may be the late spontaneous rupture of membranes (4).

6. Influence of the duration of the second stage of labor on pO_2 and acid base balance of fetal blood at birth.

No differences are found in pH, pO_2, pCO_2 or Base Deficit between the group in which the second stage lasted 15 to 60 minutes and in that in which it lasted from 60 to 210 minutes. These results agree in part with those found by Humphrey and co-workers (3) who found no changes in fetal pH (up to 30 minutes duration of the second stage) when the mother was in a position tilted to the left side, whereas a progressive fall of fetal pH occurred when the mother was in lithotomy position.

7. Influence of the duration of the second stage on Apgar score. All 12 newly born infants were vigorous with Apgar scores of 8 or higher at the first minute of life. No differences could be detected in the Apgar score at 1, 5 and 10 minutes between the group in which the second stage lasted between 15 and 60 minutes, and in that in which it lasted between 60 and 210 minutes.

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